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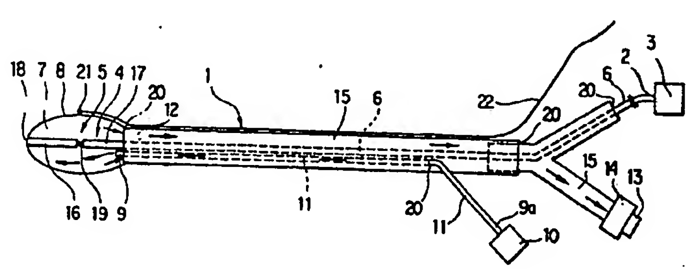
(54) Endotract antenna device for hyperthermia.

(57) The endotract antenna for hyperthermia comprising a microwave radiation antenna (5), a balloon-like member (8) made of a thin polymer film and surrounding the antenna (5) and means (10,11,14,15) for feeding and draining a cooling liquid to and from the inside of the balloon-like member (8), enables effective warming of the endotract lesion such as tumor by effectively applying the energy of the microwaves emitted from the antenna (5) to the endotract lesion.

Fig. 1



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TITLE: ENDOTRACT ANTENNA DEVICE FOR HYPERTHERMIA 0105677

DESCRIPTION

This invention concerns an endotract antenna device for hyperthermia and, more specifically, it relates to an endotract antenna device having a microwave radiation antenna applied to the hyperthermia therapy of tumors or the likes on the organs inside the body.

In the hyperthermia therapy for carcinoma, which utilizes the property of the cancer cells that they are less resistant than normal cells against heat or elevated temperature, a microwave radiation antenna is used to warm the lesion for the therapy.

It is desired that the radiation antenna is as thin as possible so that it may be inserted deeply into the endotract of the body for the therapy of organs inside the body, for example, a digestive organ and a sort of linear dipole antenna has been employed so far for such a purpose.

However, since the conventional dipole antenna is designed taking a much consideration on the dimensional stability and lacks in the flexibility, it is difficult to dispose the conventional linear dipole antenna in direct contact with a surface of the organ at the lesion, and there is fear that gases or the fluid may remain in the gap between the antenna and the surface of the organ.

As a result, the electromagnetic energy emitted from the microwave antenna of such endotract antenna device is absorbed by the body fluid in the gap, or reflected at the gap and can not always serve for effective and uniform warming of the

lesion and for effective hyperthermia therapy of the lesion.

Further, since the conventional dipole antenna comprises a pair of electrodes different from each other in the shape, it is difficult to predetermine the field pattern of electromagnetic energy emitted therefrom and, accordingly, to adequately situate the antenna relative to the lesion area.

This invention has been made in view of the foregoings and it is a first object of this invention to provide an endotract antenna device capable of closely contacting and effectively warming the lesion at the wall of the tract or lumen while avoiding localized over-heating.

A second object of this invention is to provide an endotract antenna device for hyperthermia having a microwave antenna which can be situated surely at a desired position in the tract or lumen.

A third object of this invention is to provide an endotract antenna device for hyperthermia having a microwave antenna which is highly flexible and effectively applicable to the hyperthermia therapy for the lesion in the tract or lumen.

The above-mentioned first object can be attained according to this invention by an endotract antenna device for hyperthermia comprising an antenna for radiating microwave, a balloon-like member made of a thin polymer film and surrounding the antenna, and means for feeding and draining cooling liquid to and from the balloon-like member.

The second object can be attained according to this

invention by an endotract antenna device for hyperthermia wherein said microwave antenna comprises two elongated and identically-shaped conductors formed at the top end of a coaxial cable on a straight line slightly spaced apart from each other, each having a length equal to an integral multiple of about 1/4 of the wave length of the electromagnetic waves to be emitted from the antenna.

The third object can be attained according to this invention by an endotract antenna device for hyperthermia wherein said microwave antenna comprises a rod-like insulating member made of flexible material and cylindrical conductive members made of flexible material mounted around the outer circumferential surface of the rod-like member.

This invention is to be described in more details referring to the accompanying drawings, by which the foregoing and other objects, as well as the features of this invention will be made clearer in which:

Figure 1 is an explanatory view of an endotract antenna device for hyperthermia as a preferred embodiment of this invention;

Figure 2 is an explanatory sectional view of a preferred embodiment of a microwave antenna contained in the endotract antenna device for hyperthermia;

Figure 3 is an explanatory view of the radiation pattern of the antenna shown in Figure 2; and

Figures 4 and 5 are explanatory views respectively

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for modified preferred embodiments of the microwave antenna contained in the endotract antenna device for hyperthermia.

Referring to Fig. 1, an endotract antenna device for hyperthermia 1 comprises a coaxial cable 6 for the microwave transmission connected at one end 2 to a microwave oscillator or generator 3 which can continuously generates microwaves at a frequency between 300-3,000 MHz, for example, 915 MHz and formed at the other end 4 with a sort of linear dipole antenna 5, a balloon 8 made of a flexible and elastic polymeric thin film and forming a chamber 7 of a variable volume which surrounds the microwave radiation antenna 5 and receives purified water for cooling, a feed tube 11 opened at one end 9 thereof to the water-containing chamber 7 and communicated at the other end 9a thereof with a feed pump 10 so as to feed the purified water into the chamber 7, and a draining tube 15 connected at one end 12 thereof to the balloon 8 and opened at the other end 13 thereof by way of a throttling device 14 for the water pressure control so as to drain the water from the balloon 8. In the drawing, the pump 10, the feed tube 11, the throttling device 14 and the draining tube 15 constitute means for feeding and draining the cooling water.

The frequency of the microwaves generated from the oscillator 3 to be applied to tumors at the wall of the tract is usually in the order of between 300 - 3000 MHz (wave length (λ) is in the order of 10 - 1 cm in the body fluid or at the lesion). The frequency of the microwaves may be selected from

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a plurality of oscillation frequencies that can be generated from the oscillator 3 depending on the size of the antenna 5. The output power of the oscillator 3 may be in the order of 10 to 200 watt for example.

The antenna 5 comprises tubular conductors 16 and 17 each of an identical shape and separated from each other by an insulator 19. Instead of providing the tubular conductor 16, the top end of the central conductor may be exposed about by the length of $\lambda/4$.

The antenna 5 having the electrodes of identical shapes and the coaxial cable 6 will be explained in detail hereinafter referring to the embodiments shown in Figs. 2 to 5.

The balloon 8 is secured at its base portion to the end 12 of the water-drain tube 15 and secured about at the center of its top end 19 to the top end of the microwave antenna 5.

It is preferred that the polymeric film of the balloon 8 is made of highly flexible material so that the film can be in close contact with the surface of the endotract at the lesion and that the film is made as thin as possible so that it may absorb less energy of the microwaves emitted or transmitted from the antenna 5, provided that the film has an elasticity sufficient to contain water therein under a certain pressure. In the case of using a thin rubber film for the balloon 8, the film thickness is, for instance, less than 0.5 mm (energy loss of about 30 %) and, preferably, less than 0.1 mm (energy loss of about 10 - 15 %). Although the balloon 8 in the

illustrated embodiment is shaped such that it is expandable through an oval or elliptic shape to a generally spheric shape, it may take any other configuration. For instance, the balloon 8 may be protruded longitudinally at the top end 18 and, in this case, the top end of the antenna 5 may be inserted into but not fixed to the elongated recess of the top end 18. The film material for the balloon 8 is preferably rubbery polymer material, for example, natural rubber of synthetic rubber such as silicone rubber.

In order to transmit the microwaves emitted from the antenna 5 as effectively as possible to the lesion, the cooling medium flowing the inside of the balloon 8, preferably, comprises liquid medium at least mainly composed of water so that the emitted microwaves are transmitted therein substantially at the same wavelength as in the lesion. Purified water with less transmission loss such as absorption is more preferred.

The purified water as the cooling liquid flowing inside of the balloon 8 is kept at an appropriate temperature of about 0 - 45°C and, preferably, about 15 - 42°C so that the temperature at the lesion can be maintained at 42 - 45°C by the purified water in co-operation with the antenna 5.

Further, the flow rate of the cooling water is controlled by the throttling device 14. The throttling device 14 comprises a manually- or automatically-controlled valve, the opening degree of which can be adjusted continuously. The throttling device or valve 14 also serves to produce an adequate

pressure within the balloon 8 so as to expand the balloon 8 into an intimate contact with the wall of the tract or lumen organ.

In the illustrated embodiment, the drain tube 15 is constituted as a device main body which is to be inserted through the tract or lumen and through which the coaxial cable 6 and the feed tube 11 are extended. Alternatively, the feed tube 11 may be modified to be constituted as the device main body while extending the drain tube 15 and the coaxial cable 6 the inside of the feed tube 11. In this modified embodiment, the base portion of the balloon 8 is secured to the end of the water-feed tube 11. Furthermore, the feed tube 11, the drain tube 15 and the coaxial cable 6 may be bundled in close contact together at their respective outer circumferential surfaces so that the three members form an elongated antenna device main body as a whole, with the balloon 8 being capped over the open ends of the tubes 11, 15 so as to surround the antenna 5, in the case where the assembly can be formed so smooth and thin as can be intaken, for example, from the mouth into the stomach.

The purified water may be used recyclically by connecting the drain tube 15 to the pump 10 by way of a reservoir not shown. Reference numeral 20 in the draing denotes sealed portions to prevent the leak of the water.

A thermosensor or temperature detector 21 is fixed to the outer surface of the central portion of the circumferential wall of the balloon 8 to detect the temperature at the film or

membrane surface of the balloon 8, that is, the temperature at the inner surface of the wall of the tract organ. The thermosensor 21 may be a thermocouple or thermistor. The lead 22 for the thermosensor 21 is disposed along the outer surface of the drain tube 15 constituting the device main body in the illustrated embodiment, it may, however, be passed through the inside of the drain tube 15 as the device main body if desired. The average output from the oscillator 3 and the temperature of the cooling water fed to the balloon 8 are controlled depending on the output signal from the thermosensor 21, that is, on the temperature detected by the sensor 21 so that the temperature of the lesion may be kept at about 42 - 45°C. The temperature control may be carried out automatically by a suitable control means.

In the endotract antenna device for hyperthermia 1 constituted as described above, since the microwave radiation antenna 5 is disposed to the inside of the balloon 8 through which the cooling liquid passes, the balloon 8 can be deformed just corresponding to the uneven inner profile of the wall of the tract organ and put to an intimate fitting with the inner surface of the wall, that is, the surface of the lesion by the control of the flow rate and/or the pressure of the cooling liquid flowing inside of the balloon 8, whereby the microwave emitted from the antenna 5 can be transmitted with little transmission loss to the lesion through the purified water in the chamber 7 and the thin film of the balloon 8. Furthermore,

control for the temperature and the flow rate of the cooling water flowing inside of the balloon 8 can ensure the hyperthermia therapy while preventing localized over-heating and maintaining the temperature of the wide lesion area at a temperature of between 42 - 45°C.

As described above, according to this invention, since the endotract antenna device for hyperthermia comprises a microwave radiation antenna, a balloon-like member made of a polymer thin film and surrounding the antenna, and means for feeding and draining a cooling liquid to and from the inside of the balloon-member, the energy of the microwaves emitted from the antenna can be effectively and uniformly given to the lesion in the tract or lumen organ, thereby enabling to warm the lesion effectively.

Fig. 2 shows an embodiment of the microwave antenna contained in the endotract antenna device for hyperthermia. In the Figure 2, the coaxial cable 6 for the microwave transmission comprises a central or inner conductor 31, an insulator 32, an outer conductor 33 and a protection cover 34. The cable 6 is connected at one end thereof to the microwave oscillator or generator 3 capable of continuously generating microwaves at a frequency, for example, of 915 MHz.

The coaxial cable 6 is preferably designed, for enabling effective transmission of the microwaves and easy insertion into the tract where the lesion is located, such that the cable has an outer diameter of about 2 - 10 mm and

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comprises the central conductor 31 in the form a single wire or twisted wires made of silver-plated copper wire, the insulator 32 made of a polymer material with less dielectric loss and the outer shielding conductor 33 in the form of a braided tube or helically wound braided cable made of silver-plated annealed copper wires. Further, the protection cover 34 for the cable is, preferably, made of such a polymer material as exhibiting no toxicity when put to be in contact with the tract, for example, fluoro resin, polyvinyl chloride and polyethylene.

The antenna 5 for microwave transmission or radiation is formed at the top end side 36 of the coaxial cable 6 by removing the protective cover 34 at its top end side 36. The antenna 5 comprises the tubular conductor 17 of about $\lambda/4$ in length (λ is a wave length of the microwave in the chamber 7 in Fig. 1) integrally formed with the outer conductor 33, and another tubular conductor 16, of the same shape as the tubular conductor 17, which is electrically connected at its top end 39 by means of a soldered portion 39a to the central conductor 31 and attached to the insulator 32 with a slight axial gap 41 from an extended end 40 of the tubular conductor 17. The length for each of the tubular conductors 17 and 16 may be an integral multiple more than one, that is, 2, 3, 4, ... times of the length $\lambda/4$.

The antenna 5 may be fabricated, for instance, by the following procedures. At first the central conductor 31 is exposed to about 1 mm at the top end 39 of the coaxial cable 6 (having an outer diameter, e.g., of 3 mm) and the protective

cover 34 is removed by the length of about $\lambda/2$ (e.g., about 22 mm for the case of 915 MHz) at the top end 36 to reveal or expose the outer conductor 33 composed of the braided tubes. Then, the exposed portion of the conductor 33 about $\lambda/2$ in length is entirely impregnated with a solder to form a tubular body uniformely deposited or coated with the solder over the exposed portion. Thereafter the tubular body is divided into two exposed tubular conductors 16 and 17 each of a same length by forming a circular slit at a position of about $\lambda/4$ (for example, of about 11 mm) from the top end of the tubular body. Then, the tubular conductor 16 at the top end side 39 is drawn by about 1 mm toward the top end 39 and electrically connected by means of soldering with the projected end 31a of the central conductor 31.

The central conductor 31 and the tubular conductor 19 on the side of the top end 39 may be electrically connected not only by way of soldering but also with an annular conductor plate made of copper or the like. The tubular conductor 16 may be formed by fitting a tubular conductor of about $\lambda/4$ in length made of copper or like other metal over the insulator 32, instead of using the braided tubes impregnated with the solder. Furthermore, the tubular conductor may have an end wall formed with an aperture through which central conductor 31 is fitted. In addition, the other tubular conductor 17 may also be formed with a copper tube or the like, which is fitted over the insulator 32, electrically connected with the outer conductor 33

and secured to the coaxial cable 6.

At first, the braided portion for forming the tubular conductor 17 may be exposed to more than $\lambda/4$ in length and inpregnated with solder or the like to form an exposed tubular conductor of more than $\lambda/4$ in length. In this case, insulating resin adhesives or the like can be applied for covering a portion of the tubular conductor near the opening end of the protective cover 34 in such a way that the tubular conductor may be exposed over length of about $\lambda/4$ and that liquid materials may not intrude between the tubular conductor 17 and the outer cover 34 to the inside of the axial cable 6.

When the antenna 5 was connected to the microwave oscillator 3 operating at 915 MHz while matching an impedance as long as possible, the antenna had characteristics of an output power of 15 watt and a reflection factor of 5 %. The microwave radiation pattern at 915 MHz from the antenna 5 immersed in a physiological saline water was as shown in Fig. 3. Fig. 3 shows an isothermal curve at 40°C by the lines 43, which are rotationally symmetrical about the center line 37a of the antenna 5 and are also symmetrical for the mirror operation or reflection in an imaginary plane passing through the gap 41 in perpendicular to the line 37a. The line 43 exhibits peaks 43a at portions facing to the gap 41. Accordingly, effective therapy can be carried out by disposing the antenna 5 so as to oppose the peak 43a, that is, the gap 41 to the lesion, because the microwave antenna 5 is formed vertically symmetrical with respect

to the gap 41 and because the electric power is fed to the tubular conductors 16 and 17 of the antenna 5 from the separated side ends 44 and 45 respectively.

Instead of forming the microwave antenna directly on the extension of the intermediate insulator 32 for the coaxial cable 6 as shown in Fig. 2, a microwave antenna 59 may be modified as shown in Fig. 4, in which a cylindrical insulating resin tube 50 of about $\lambda/2$ in length is fitted over the extension 32a of the insulator 32 slightly longer than $\lambda/2$ in length and cylindrical metal tubular conductors 51, 52 made of copper and the like of about $\lambda/4$ in length, respectively, are fitted while separated from each other by a gap 53 over the resin tube 50. A central conductor 31 of a coaxial cable 6 is electrically connected by means of soldering or the like to the top end 54 of the tubular conductor 51 remote from the tubular conductor 52 by way of a disc 56 made of copper or like other metal and formed with an aperture 55. The outer conductor 33 is electrically connected by means of soldering or the like to the end 57 of the tubular conductor 52 remote from the tubular conductor 51 by way of conductor wires 58. The conductor wires 58 may be formed by partially releasing and spreading the braided tube of the outer conductor 33. The characteristics and the radiation pattern of the antenna 59 were the same as those of the antenna 5.

As described above, since the microwave antenna contained within the balloon of the endotract antenna device for hyperthermia according to this invention comprises two

identically-shape elongated conductors of about $\lambda/4$ in length formed at the top end of a coaxial cable on a straight line and slightly spaced apart from each other, the radiation energy is made at the maximum near the separated portion or gap between the two conductors and the effective therapy can be carried out by opposing the separated portion to the lesion.

Fig. 5 shows another modified embodiment of the microwave antenna according to this invention, in which a flexible coaxial cable 6 for transmitting microwaves has the same constitution as the coaxial cable shown in Fig. 2 and it is connected at one end thereof to a microwave oscillator 3 capable of continuously generating microwaves. The central conductor 31 of the coaxial cable is slightly projected at the top end 67 thereof.

A flexible tube 68 made of flexible polymer material such as soft polyvinyl chloride is supported at its base end 68a to the top end of the coaxial cable 6 and the top end of the flexible tube 68 is projected by about $\lambda/4$ or more in length from the coaxial cable 6. The tube 68 has a radial penetrating hole 70 at the position of about $\lambda/4$ from the top end 69 and another radial penetrating hole 72 at the position of about $\lambda/4$ or more from the top end, on the opposite side to the hole 70 and generally opposed to the top end 71 of the outer conductor 33 of the coaxial cable 6.

While the flexible tube 68 has a larger inner diameter than the outer diameter for the coaxial cable 6 so as to be kept highly flexible the inner diameter of the tube 68 may be the same as the outer diameter of the coaxial cable 6, provided that the coaxial cable 6 can be inserted and that the assembly of the tube 68 and the cable is kept highly flexible.

The flexible tube 68 may be made of flexible polymer material such as rubber and high pressure process polyethylene.

Electrically conductive and flexible cylindrical members 73 and 74 are fitted over the flexible tube 68 while spaced apart, for example, by about 1 mm from each other so that their opposing ends 75 and 76 are situated at the openings of the holes 70 and 72 respectively. The hollow cylindrical members 73 and 74 are made of braided tubes made of, for example, copper wires braided in a hollow cylindrical configuration and have about $\lambda/4$ in length (for example, 11 mm at 915 MHz) in the condition fitted to the tube 68. The cylindrical members 73 and 74 are secured at both ends 75, 77 and 76, 78 respectively to the tube 68. The cylindrical member 73 is electrically connected at its one end 75 to the top end 67 of the central conductor 31 by way of a conductor wire or lead 79 passed through the hole 70, while the cylindrical member 74 is electrically connected at its one end 76 to the top end 71 of the outer conductor 33 by way of a conductor wire or lead 80 passed through the hole 72.

A cap 81 rounded at the top end is mounted to the top end 69 of the flexible tube 68 so as to facilitate the insertion

of the flexible microwave antenna 82, into the tract, comprising the flexible and electrically conductive cylindrical member 73 of about λ/4 in length connected to the central conductor 31 and the flexible and electrically conductive cylindrical member 74 of about λ/4 in length connected to the outer conductor 33. The cap 81 preferably made of flexible polymer material prevents the body fluid from intruding to the inside of the tube 68 in cooperation with the resin adhesives filled in the holes 70 and 72.

The flexible microwave antenna 82 having the foregoing constitution may be assembled, for example, by fitting the braided tubes 74 and 73 over the tube 68 in which the holes 70 and 72 are formed at predetermined positions, securing the tube 68 over the top end of the coaxial cable 6, connecting the braided tubes 74 and 73 with the outer and the central conductors 33 and 31 by way of the conductor wires 80 and 79 by means of soldering or the like, securing the braided tubes 74 and 73 to the tube 68 so as to have the predetermined length of λ/4 at the position spaced apart by about 1 mm from each other, further securing the conductor wires 80 and 79 to the holes 72 and 70 respectively and mounting the cap 81 over the tube 68 and the braided tube 73.

Alternatively, the outer conductor 33 may be connected electrically to the flexible hollow cylindrical member 73 at the top end, while the central conductor 31 may be connected electrically to the other cylindrical member 74. The position

and the number for the penetrating holes 70 and 72 in the tube 68 are determined in view of the current distribution and not restricted to the illustrated positions generally diametrically opposing each other.

In a case where it is desired to constitute a particularly thin antenna or the like, a pair of fine or thin flexible braided tubes 73 and 74 may be directly fitted around the outer circumference of the flexible protective cover 34 of the coaxial cable 6. Furthermore, the tubular braided conductor of the outer conductor 33 may be used directly as a pair of flexible braided tubes 73 and 74.

The flexible microwave antenna 82 having the foregoing constitution can be in close contact with the tract wall at the lesion and deeply inserted into the tract because of its flexibility, and thus can be effectively applied to the therapy of the lesion. In addition, in a case where the antenna 82 of 18 W in output power was deformed or curved by transversely or laterally displacing the top end 83 of the antenna 82 by 10 mm from its straightly extended position, the reflection factor can be maintained not more than 5-7%. This result shows that, although the antenna deformation has been avoided in the prior art fearing the degradation in the antenna characteristic, the flexible antenna 82 according to this invention can be effectively applied to the hyperthermia therapy with less fear of degrading the characteristic.

As described above, according to this invention, since

the flexible microwave antenna contained in the endotract heating antenna device comprises flexible cylindrical members made of electrically conductive material mounted to the outer circumference of a rod-like member made of flexible and insulating material, it can be effectively applied for the therapy of the lesion in the tract or lumen.

The microwave antenna described herein above can be used not only in a condition contained in the endotract antenna device for hyperthermia but also in a condition in direct contact with the body fluid or the lesion.

~~WHAT IS CLAIMED IS:~~ CLAIMS

1. An endotract antenna device for hyperthermia comprising an antenna for radiating microwave, a balloon-like member made of a polymer thin film and surrounding said antenna, and means for feeding and draining a cooling liquid to and from an inside of said balloon-like member.

2. The antenna device as defined in claim 1, in which the microwave radiation antenna comprises two elongated and identically-shaped conductors arranged on a straight line and slightly spaced apart from each other, each having a length equal to an integral multiple of about 1/4 of a wavelength of the microwave to be emitted from said antenna.

3. The antenna device as defined in claim 2, in which the two identically-shaped conductors are formed at the top end of a coaxial cable, and comprise a tubular conductor of a length of about 1/4 of the wavelength electrically connected to either one of a central conductor or an outer conductor of the coaxial cable, and another tubular conductor of a length of about 1/4 of the wavelength electrically connected to the other one of the outer conductor or the central conductor of the coaxial cable.

4. The antenna device as defined in claim 3, in which said two tubular conductors are attached over an insulator

between the central conductor and the outer conductor.

5. The antenna device as defined in claim 3, in which the microwave radiation antenna comprises a hollow cylindrical insulating resin tube having a length of about 1/2 of the wavelength fitted over an insulator disposed between the central conductor and the outer conductor of the coaxial cable, and said two tubular conductors forming the gap therebetween are fit around the resin tube, each of said two tubular conductors being made of a cylindrical metallic tube.

6. The antenna device as defined in any one of claims 3 to 5, in which the coaxial cable comprises the central conductor composed of a single wire or twisted wires made of silver-plated copper wire, the insulator between the central conductor and the outer conductor made of a polymer material with less dielectric loss, the outer shielding conductor composed of a braided tube or a helically wound braided cable made of silver-plated annealed copper wires, and a protective cover made of a polymer material disposed to the outer side of the outer conductor.

7. The antenna device as defined in claim 1, in which the microwave radiation antenna comprises a pair of flexible tubular members made of electrically conductive material for microwave radiation mounted to the outer circumference of a rod-like member made of a flexible and insulating material.

8. The antenna device as defined in claim 7, in which the rod-like member comprises a hollow member and contains an end portion of a coaxial cable including a central conductor, an outer conductor, an insulator between the central conductor and the outer conductor, and a protective cover at the outerside of the outer conductor therein, the coaxial cable being electrically connected to the tubular members, and the rod-like member projecting at the top end thereof from relative to the end portion of the coaxial cable.

9. The antenna device as defined in claim 7 or 8, in which each of the flexible tubular members made of the electrically conductive material comprises a braided metallic tube of a length of about 1/4 of the wavelength of the microwave fitted over the rod-like member while slightly spaced apart from each other.

10. The antenna device as defined in claim 1, in which said radiation antenna is connected by way of a coaxial cable to a microwave oscillator.

11. The antenna device as defined in claim 1, in which said radiation antenna is fixed at a top end thereof with a central portion of a top end of said balloon-like member.

12. The antenna device as defined in claim 1, in which the

thin polymer film of said balloon-like member is flexible and elastic.

13. The antenna device as defined in claim 1, in which the thin polymer film is made of rubber.

14. The antenna device as defined in claim 13, in which the rubber is synthetic rubber.

15. The antenna device as defined in claim 13, in which the rubber is natural rubber.

16. The antenna device as defined in claim 1, in which said feeding and draining means comprises a feeding tube communicated at one end thereof with said balloon-like member so as to feed the cooling liquid to the inside of said balloon-like member and a draining tube communicated at one end thereof with said balloon-like member so as to draining the cooling liquid from said balloon-like member.

17. The antenna device as defined in claim 16, in which said feeding and draining means further comprises a pump connected to an other end of the feeding tube so as to supply the cooling liquid by way of the feeding tube to the inside of said balloon-like member.

18. The antenna device as defined in claim 17, in which said feeding and draining means further comprises a throttling means for controlling a flow rate or a pressure of the cooling liquid flowing the inside of said balloon-like member.

19. The antenna device as defined in claim 18, in which the throttling means is disposed at an other end of the draining tube.

20. The antenna device as defined in claim 19, in which said balloon-like member is capped liquid-tightly over the one end of the draining tube, the feeding tube is inserted in the draining tube at a side of the one end of the draining tube, and a transmission line for connecting a microwave oscillator with said radiation antenna is inserted in the draining tube.

21. The antenna device as defined in claim 19, in which said balloon-like member is capped liquid-tightly over the one end of the feeding tube, the draining tube is inserted in the feeding tube at a side of the one end of the feeding tube, and a transmission line for connecting a microwave oscillator with said radiation antenna is inserted in the feeding tube.

22. The antenna device as defined in claim 16, in which said feeding and draining means comprises means for controlling a temperature of the cooling liquid to be supplied by way of the

feeding tube to said balloon-like member.

23. The antenna device as defined in claim 1, in which the cooling liquid is water.

24. The antenna device as defined in claim 23, in which the water is purified water.

25. The antenna device as defined in any one of claims 1 to 24, in which a thermosensor is disposed on the surface of the balloon-like member.

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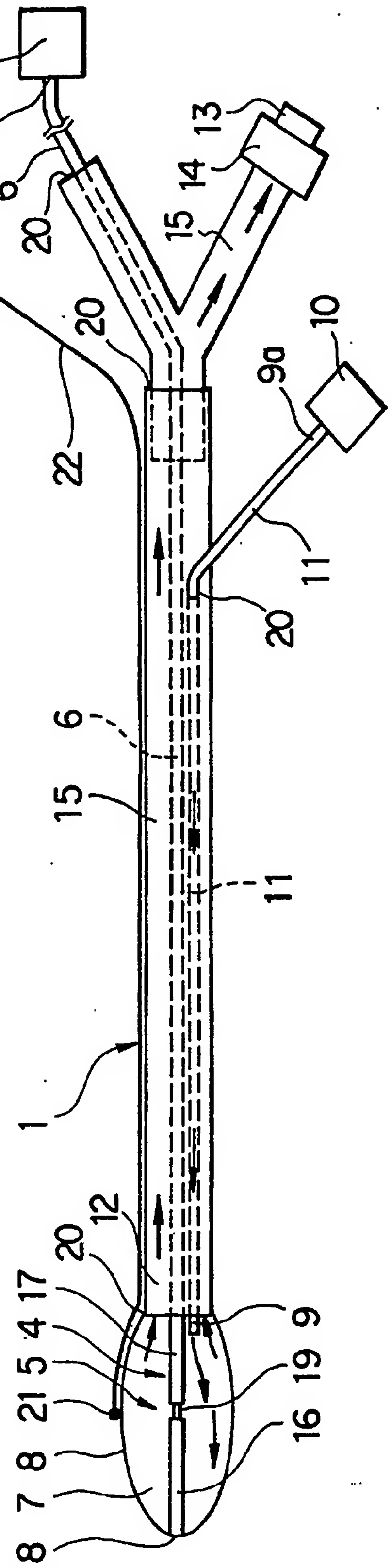

Fig. 1

Fig. 2

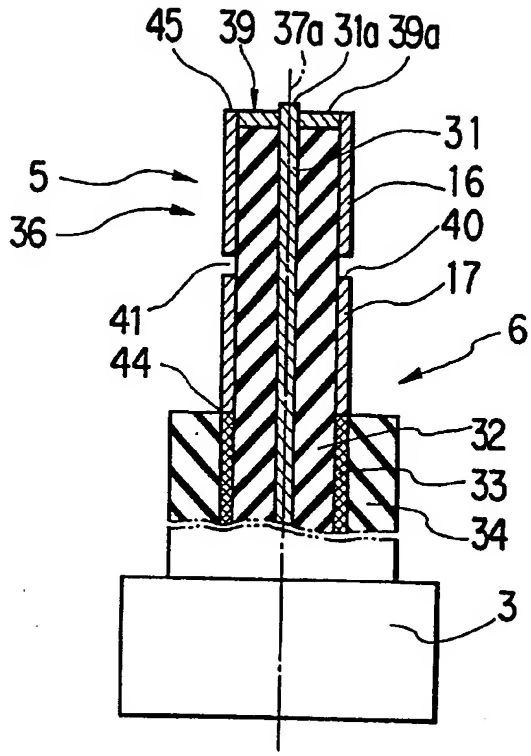
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Fig. 3

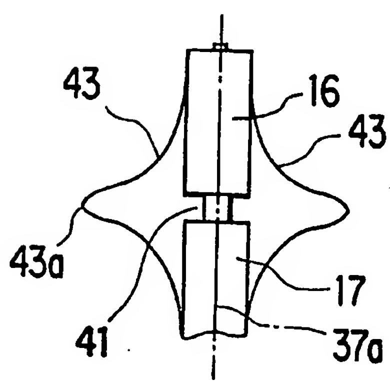
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Fig. 4

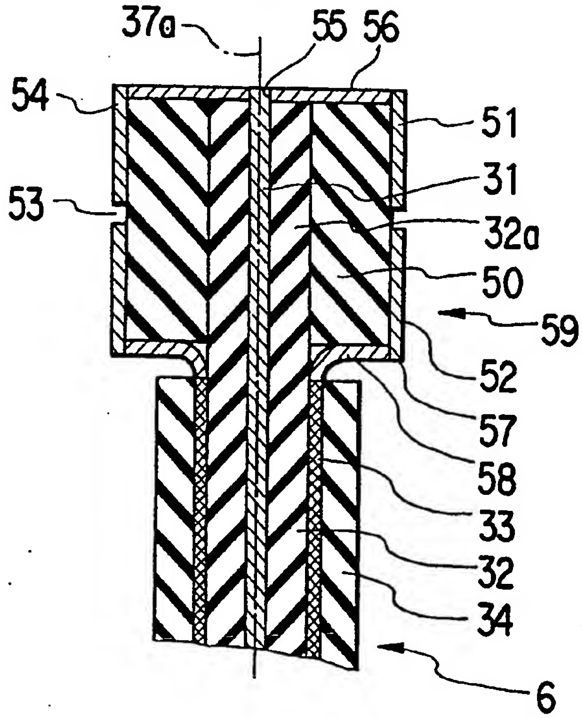
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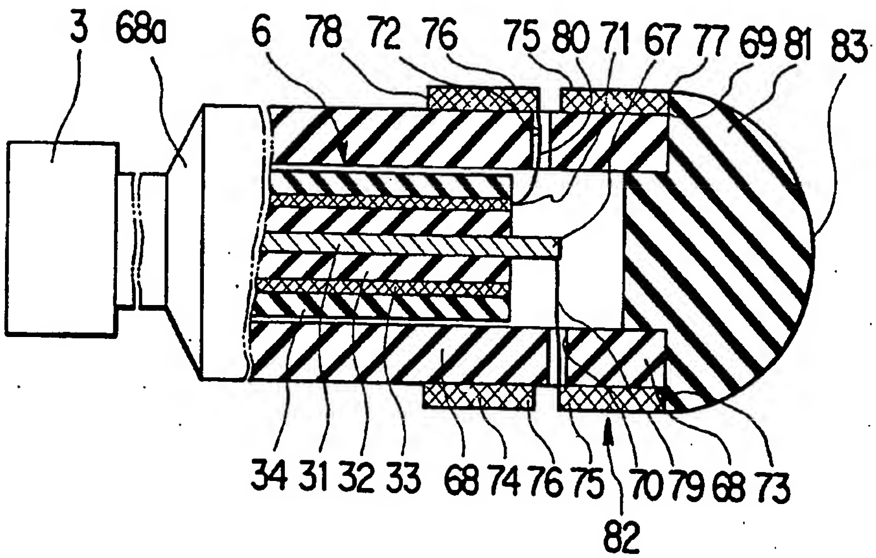
Fig. 5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